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(54) Record carrier, method of and information recording device for obtaining such record carriers, and information recording device comprising anti-copy means to inhibit unauthorized copying.

(57) A record carrier is disclosed carrying subcode information in addition to the main information. The subcode information comprises "copy" bits of alternating logic values to indicate that the recorded information is a copy. Moreover, a method and recording device (72) for obtaining such record carriers are described. Finally, a recording device (71; 72) is described, which comprises a detection circuit (85) which detects the presence of "copy" bits of alternating logic values in the received information, and which comprises a decision circuit (94; 95) for deciding whether recording of the received inforrnation is allowed depending upon the detection of the presence of the "copy" bits of alternating logic values.

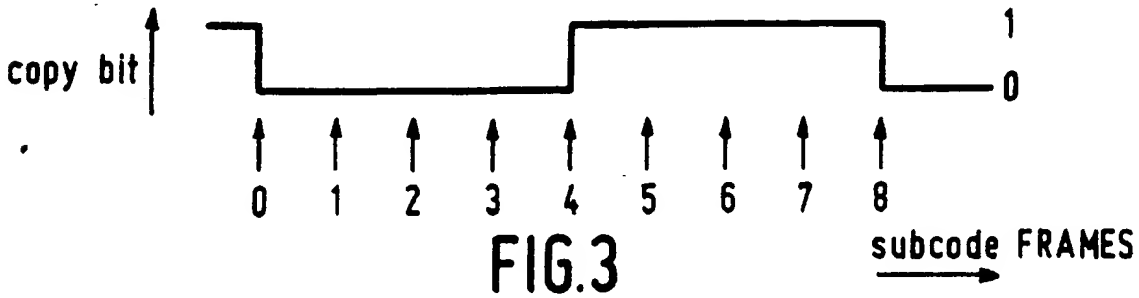

FIG.3

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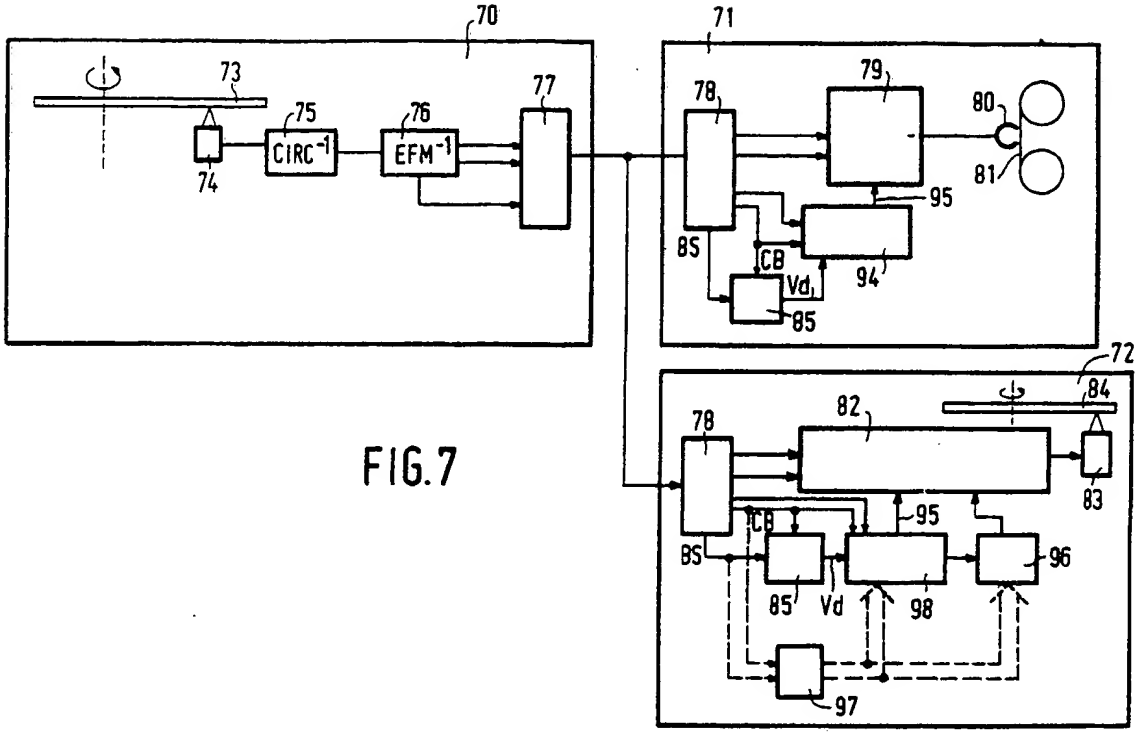
70
71
72
73
74
75
CIRC⁻¹
76
EFM⁻¹
77
78
79
80
81
95
BS
CB
Vd
94
85
82
84
83
96
97
98

FIG.7

RECORD CARRIER, METHOD OF AND INFORMATION RECORDING DEVICE FOR OBTAINING SUCH RECORD CARRIERS, AND INFORMATION RECORDING DEVICE COMPRISING ANTI-COPY MEANS TO INHIBIT UNAUTHORIZED COPYING.

The invention relates to a record carrier carrying main information together with a series of subcode frames which each comprise a "copy" bit.

The invention further relates to a method of obtaining a record carrier, information, together with a series of subcode frames which each comprise a "copy" bit being recorded on the record carrier.

The invention further relates to an information recording device for obtaining a record carrier, which device is constructed to record on the record carrier main information together with a series of subcode frames which each comprise a "copy" bit.

Finally, the invention relates to an information recording device for recording main information received together with a series of subcode frames which each comprise a "copy" bit, which device comprises anti-copy means to inhibit unauthorized copying of the received information, which anti-copy means comprise decision means for deciding whether recording of the received information is permissible depending upon the logic values of the received "copy" bits, and means responsive to a decision that recording is not permissible to inhibit recording.

Record carriers carrying which digitised audio information have been available for a considerable time. Such a record carrier may be, for example, an optically readable disc, such as a "Compact Disc" or a magnetic tape, such as "DAT" cassette tapes. The advantage of digitised audio information is the extremely high quality.

Another property of digitised information is that it can be copied to an almost unlimited extent without any significant loss of quality.

This last-mentioned property constitutes a substantial problem when consumer equipment by means of which digital audio information cannot only be reproduced but can also be recorded is to be put on the market.

This is because such an apparatus makes for large scale copyright infringement by the customer in that the contents of a record carrier carrying digitised audio information is simply copied.

Since there is no loss of quality as a result of copying there is hardly any reason for the consumer to purchase a comparatively expensive original which is subject to copyright if the original or a copy thereof is available. All this leads to a substantial loss of copyright revenues.

A recent copy protection method which mitigates the above drawbacks is known as the "Solocopy" copy-protection system. This method allows only first-generation copies to be made of record carriers carrying original information. In the "Solocopy" copy-protection system it is assumed that the digital information to be recorded complies with a standard-audio interface format, as described in, for example, the first edition (1989.03) of the IEC-958 standard. Such a format comprises mairi information channels and subcode information channels. The subcode information signal includes an "copy" bit indicating whether the information may be copied freely, and a category code indicating the source of the recorded information.

In accordance with the "Solocopy" copy protection method it is ascertained by means of the category code and the "copy" bit whether the applied information may be copied. For example, copying is always allowed if the category code indicates that the information originates from a CD player. This is based on the assumption that a CD player is only capable of playing CDs of the read-only type. However, in the meantime, CD recording devices have been developed by means of which information can be recorded on a record carrier, which can subsequently be read by a standard CD player for reading CDs of the read-only type.

Therefore, the prior-art "Solocopy" copy-protection method does not inhibit copying of CD information recorded on an inscribable optical record carrier. It is an object of the invention to provide means which mitigate this drawback.

In accordance with a first aspect of the invention a record carrier of the type defined in the opening paragraph is characterized in that the logic value of the "copy" bits of consecutive sub-code frames alternate.

A method of the type defined above, for obtaining such a record carrier is characterized in that during recording logic values are assigned to the "copy" bits of consecutive sub-code frames in accordance with an alternation pattern.

A device of the type defined above, for obtaining record carriers in accordance with the invention, is characterized in that the device comprises assignment means for assigning the logic values in accordance with an alternation pattern to the "copy" bits of consecution subcode frames of information to be recorded.

Recording "copy" bits with alternating logic values falls within the scope of the standard Compact Disc Digital Audio system, so that it remains possible for the record carriers to be read by means of existing CD players. When standard CD information is recorded on an inscribable record

carrier this makes it possible to indicate by means of an alternating logic value of the "copy" bit in the recorded information that the information recorded on the relevant record carrier is a copy without thereby adversely affecting the process of reading the information by means of a standard CD player.

The use of alternating patterns of different forms enables the generation number of the copy in the copying cycle to be specified. For example, in the case that a copy-protection method allows both first and second generation copies to be made it is possible to distinguish between first-generation, second generation and higher-generation copies.

Information patterns which are very suitable because of their simplicity and which enable the generation number to be specified are periodic patterns in which the generation number is represented by the duty cycle of the pattern, i.e. the ratio between the number of "copy" bits of a first logic value in a period and the total number of "copy" bits in this period.

In accordance with a second aspect of the invention copying of the record carrier in accordance with the invention can be inhibited in a very simple manner by the use of the information recording device for recording the main information, which is received together with a series of subcode frames which each comprise a "copy" bit, which device comprises anti-copy means for inhibiting unauthorized copying of the received information, which anti-copy means comprise decision means for deciding whether recording of the received information is allowed depending on the logic value of received copy bits, and means responsive to a decision that recording is not allowed to inhibit recording, characterized in that the device comprises detection means for detecting an alternation pattern in the logic values of the received "copy" bits, the decision means being adapted to decide whether recording is allowed depending upon detection of the alternation pattern.

This device has the advantage that the information to be recorded can be transmitted directly in the format prescribed by the digital audio interface standard IEC-958, without additional steps being required during information reading. Indeed, in conformity with this standard the logic value of the "copy" bit in the subcode for the digital audio interface standard is equalised to the "copy" bit of the source of the information, i.e. in the present case the "copy" bit of the information read from the record carrier by the read device.

By detecting the various alternation patterns it is again possible in taking the decision whether or not recording is permitted to distinguish between first and higher-generation copies.

The recording device may comprise a device constructed to make recordings on a record carrier of another type, for example a DAT cassette tape, than that from which the information originates, for example an inscribable CD.

If the recording device is intended for recording information on a record carrier of the same type as that from which the information with the alternating logic value of the "copy" bit originates, it is desirable to provide this recording device with means which cause "copy" bits with alternating logic values to be recorded.

The invention and further advantages thereof will now be described in more detail with reference to Figs. 1 to 9, in which

Figs. 1 and 2 represent the format of a standard CD signal,

Figs. 3 and 4 show possible forms of the alternating pattern of the logic values of the "copy" bits for a record carrier in accordance with the invention,

Fig. 5 shows an information recording device in accordance with the invention,

Fig. 6 shows in detail a circuit for use in the information recording device shown in Fig. 5,

Fig. 7 shows an information copying system employing information recording devices in accordance with the invention,

Fig. 8 shows in detail a detection circuit for use in the information recording devices shown in Fig. 7, and

Fig. 9 is a flow chart of a program for determining whether recording of the received information is allowed.

Fig. 1 illustrates the data format of a digital signal in conformity with the CD standard. Such a signal is divided into blocks (Block) of 98 FRAMES each. Each FRAME comprises data bits (DB) representing the main information (MAIN DATA) and subcode information (subcode DATA). The subcode information of FRAME 2 through FRAME 97 comprises eight subcode bits for each FRAME. The subcode bits within a block constitute subcode frames of the P-W-subcode channels, each subcode frame comprising 96 subcode bits.

Fig. 2 illustrates the format of the subcode frame of the subcode Q channel. This subcode frame comprises a 4-bit "control" group, including one bit referred to as the "copy" bit. The logic value of the "copy bit" indicates whether the associated main information may be copied freely. For the well known Compact Disc the logic value of the "copy" bit is the same throughout the disc, which means that in every subcode frame on the Compact Disc the copy bit either has the logic value "1" or the logic value "0".

In the case of a record carrier in accordance with the invention the logic values of the "copy" bits alternate, for example as illustrated in Fig. 3

and Fig. 4, in order to indicate that the recorded information is a copy.

In the case of the alternation pattern shown in Fig. 3 the values of the copy bits alternate periodically, 4 subcode frames each comprising a "copy" bit of the logic value "0" each time alternating with 4 subcode frames each comprising a "copy" bit of the logic value "1".

In Fig. 4 the logic values of the copy bits also vary periodically, but here 6 subcode frames comprising copy bits of the logic value "0" each time alternate with 2 subcode frames comprising copy bits of the logic value "1". Recording different alternation patterns of different forms, as illustrated in Figs. 3 and 4, also provides the possibility of indicating on the record carrier whether the copy is a first-generation copy or a second or higher-generation copy.

In the alternation patterns illustrated in Figs. 3 and 4 the duty cycle differs, which is the ratio between the number of "copy" bits of the logic value "0" in a period and the total number of bits in each period of the alternation pattern.

It will be evident to those skilled in the art that the alternation patterns can also specify the generation number of a copy in a copying cycle in a different manner, for example by periodic alternation patterns of different period lengths.

By means of a suitable d.c. free coding of the logic values of the "copy" bits it is also possible to transmit information about the generation number and, if desired, other information via the "copy" bit.

Transmitting information via an alternating logic value of the "copy" bit has the advantage that this remains within the scope of the CD standard. This means that the information can be read by means of a standard CD player.

Fig. 5 shows an embodiment of a recording device for obtaining a record carrier on which the logic values of the "copy" bits alternate. The recording device comprises a cascade arrangement of a CIRC encoder 50 and an EFM modulator 51 for converting the applied digital information, originating from for example analog-to-digital converters, into a format prescribed by the CD standard. The EFM modulator 51 supplies an output signal of this format to a control circuit 52 for an optical write head 53 arranged opposite a rotating optical record carrier 54 of an inscribable type. The recording device further comprises a clock signal generation circuit 55 for generating clock signals for controlling the CIRC encoder 50 and the EFM modulator 51. The EFM modulator further comprises inputs for applying subcode information to the EFM modulator 51. The logic value of the "copy" bit to be recorded is supplied to the EFM modulator 51 by a circuit 57 via a signal line 56. The circuit 57 supplies a periodic signal to the EFM modulator. This periodic signal can be derived, for example by frequency division, from a clock signal which is applied to the circuit 57 by the clock signal generation circuit 55 via a signal line 58.

Fig. 6 shows another embodiment of the circuit 57 enabling an alternation pattern of a specific form to be selected from a plurality of alternation patterns of different forms. For this purpose the circuit 56 comprises a circuit 60 which derives a plurality of signals havingalternation patterns of different forms, for example alternation patterns having different "duty cycles", from the clock signal applied via the signal line 58. These signals are applied to a selection circuit 61 which transfers one of the applied signals to the signal line 56 depending on a control signal Vs.

Since alternating logic values of the "copy" bits on the record carrier in accordance with the invention indicate that the recorded information is a copy further copying can be inhibited simply by detecting whether the logic values of the copy bits in the information applied for recording alternate and inhibiting recording if "copy" bits of alternating logic values are detected.

Fig. 7 shows an embodiment of an information copying system in which this is realized. This information copying system comprises an optical read device 70 for reading optical discs, a magnetic recording device 71, and an optical recording device 72 for recording information read by the read device 70.

The read device 70 is of a customary type adapted to read CD information from an optical record carrier 73. For this purpose the read device 70 comprises an optical read head which is coupled to a cascade arrangement of a customary CIRC decoding circuit 75 and an EFM demodulator 76, which for example form part of an integrated circuit of the type SAA 7210 marketed by PHILIPS. Such an EFM demodualtor 76 produces tw digitised stereo audio information signals and a subcode signal on its outputs. These signals are applied to a formatting circuit 77, for example of the type SAA 7220, which converts the received information into a format prescribed by a digital audio interface standard (IEC 950). This digital audio interface format comprises blocks of 192 main information frames, and a plurality of interface subcode frames. These subcode frames each comprise an interface "copy" bit whose logic value, in accordance with the digital audio interface standard, is taken over from the "copy" bit in the subcode information of the information being read.

An output signal complying with the digital audio interface standard is applied to reformatting circuits 78 of the read devices 71 and 72.

The reformatting circuits 78 convert the received information into a format suitable for pro-

cessing by the recording devices 71 and 72.

The reformatting circuits may be constituted, for example, by an integrated circuit of the type SX 23053 marketed by SONY. This type of reformatting circuit produces the main information and the subcode information on its outputs. The circuit further comprises an output to which "copy"-bit information CB relating to the logic value of the received interface "copy" bit is applied and an output to which a block synchronisation signal BS is applied to indicate the beginning of each digital audio interface block received.

In the magnetic recording device 71 the information supplied by the reformatting circuit 78 is applied to a circuit 79 of a customary type for driving a magnetic-head system 80 for recording the received information on a DAT cassette tape 81. Similarly, the information supplied by the reformatting circuit 78 in the optical read device is applied to a circuit 82 of a customary type, which comprises for example an EFM modulator and CIRC encoder, to drive an optical write head 83 for recording the received information on an optical record carrier 84. In the recording devices 71 and 72 the "copy"-bit information CB and the block synchronisation signals BS supplied by the reformatting circuit 78 are applied to a detection circuit 85 for detecting whether the logic value of the received "copy"-bit information alternates.

The detector circuit 85 supplies a detection signal Vd if the alternating logic value of the "copy"-bit information is detected.

Fig. 8 shows an example of a detection circuit 85 comprising three clocked D flip-flops 90, 91 and 92. The block synchronisation signal BS supplied by the reformatting circuit is applied to the clock inputs of the flip-flops 90, 91 and 92. The interface "copy"-bit information CB is applied to the data input of the flip-flop 90. The output of the flip-flop 90 is connected to the data input of the flip-flop 91 and to an input of an Exclusive-OR gate 93. Another input of the Exclusive-OR gate 93 is connected to the output of the flip-flop 97 The output of the Exclusive-OR gate 93 is connected to the data input of the flip-flop 92. The output signal on the output of the flip-flop 93 serves as the detection signal Vd. The circuit shown in Fig. 8 operates as follows. If the logic value of the interface "copy" bit changes the logic value of the signal on the input of the flip-flop 91 at the instant at which the first "copy" bit of changed logic value reaches the input of the flip-flop 91 will no longer correspond to the logic value of the signal on the output of the flip-flop 91. In that case the logic value of the output of the Exclusive-OR gate becomes a logic "1" value. This value is latched in the flip-flop 92, after which the detection signal Vd also assumes the logic "1" value.

In the recording device 71 the detection signal Vd is applied to a decision circuit 94. Moreover, the subcode information supplied by the reformatting circuit 78 is applied to the decision circuit 94. On the basis of the received subcode information and the detection signal Vd the decision circuit 94 decides whether recording of the received main information is allowed. If recording is not allowed the decision circuit generates a control signal which is applied to the control circuit 79 via the signal line 95, the control circuit 79 being of $\overline{a}$ type which is disabled in response to the control signal applied via the signal line, so that recording of $\overline{\text{information}}$ is inhibited. The decision circuit 94 may comprise, for example, a microcomputer loaded with a suitable program. However, before this program is described in detail that part of the received subcode information of the digital audio interface format will be described which is important for a correct understanding of the decision criteria. In particular the subcode C-channel of the digital audio interface format of the received subcode information is of interest. This subcode C-channel comprises subcode frames of 192 bits. These subcode frames indicate whether the information stems from a source intended for professional use. Moreover, it is indicated whether the associated information stems from an audio source. Moreover, for sources intended for consumer applications the subcode C-channel contains a category code indicating the type of source. This may be for example a 2-channel Compact Disc audio system, a 2-channel digital audio type player, etc.

Fig. 9 is a flow chart of a decision program for determining whether recording of the received information is allowed. This decision program is based on the decision program employed in the "Solocopy" system. However, the program has been adapted to make the decision dependent upon the detection of alternating logic values of the "copy" bits.

In step S1 of the program it is ascertained by means of the information from the subcode C-channel whether the information originates from an information source intended for professional uses. If this is the case, recording is inhibited in step S2. In step S3 it is checked whether the received information is audio information. If this is not the case, recording is inhibited in step S4. In step S5 it is checked whether the received category code occurs in the list of known category codes. If this is not the case, recording is enabled in step S6 and, in addition, information is recorded on the tape 81 to indicate that the recorded information is a copy. If the information is read subsequently a category code is assigned to the information to denote that recording is not allowed. However, the manner in which this is effected falls beyond the scope of the

present invention and is therefore not described in detail.

In step S7 it is checked whether the information stems from an analog-to-digital converter. If this is the case, recording is enabled in step S8. In step S9 it is determined on the basis of the received detection signal Vd whether the logic values of the received interface copy bits alternate. If the values alternate, recording is inhibited in step S10. In step S11 it is ascertained on the basis of the received logic values of the copy bits whether the relevant information may be copied freely. If this is the case, recording is enabled in step S12, information being added to indicate that the recorded information may be copied freely.

In step S13 it is checked whether the category code specifies a source for which copying of the supplied information is allowed. If this is the case recording is enabled in step S14. If it is not the case, recording is inhibited in step S15.

The recording device 72 comprises a decision circuit 98 which is largely identical to the decision circuit 94. However, in the case that information is recorded which should not be copied any more, the decision circuit 98 generates a control signal for a circuit 96 which causes "copy" bits of alternating logic values to be recorded.

For the circuit 96 the circuits 57 described above may be employed.

It is also possible to provide the circuit 72 with a detection circuit 97 for detecting the generation number in a copy cycle for the received information on the basis of the form of the alternation pattern. The decision whether the received information may be recorded or not can then be taken on the basis of the detected generation number of the information. For example, copying of a first-generation copy may be allowed while copying of a second generation copy is not allowed.

The circuit 98 should be adapted in such a manner that depending on the detected generation number it generates an alternation pattern indicating a higher generation number than the detected generation number.

In the foregoing the invention has been illustrated for a record carrier carrying a standard CD signal having "copy" bits with alternating logic values to indicate that the recorded information is a copy. However, it is to benoted that, in principle, the invention may be applied to any record carrier which in addition to the main information carries subcode information comprising a "copy" bit.

Claims

1. A record carrier carrying main information together with a series of subcode frames which each comprise a "copy" bit, characterized in that the logic values of the "copy" bits of consecutive subcode frames alternate.

2. A record carrier as claimed in Claim 1, characterized in that the form of the pattern indicates the generation number of the information in a copying cycle.

3. A record carrier as claimed in Claim 2, characterized in that the detected pattern is a periodic pattern in which the ratio between the number of "copy" bits of a first logic value in a period and the total number of "copy" bits in said period indicates the generation number.

4. A record carrier as claimed in Claim 1, 2 or 3, characterized in that the recorded information is a standard CD signal.

5. A method of obtaining a record carrier as claimed in Claim 1, 2, 3 or 4, main information together with a series of subcode frames which each comprise a "copy" bit being recorded on the record carrier, characterized in that during recording logic values are assigned to the "copy" bits of consecutive subcode frames in accordance with an alternation pattern.

6. A method as claimed in Claim 5, characterized in that the information to be copied is previously recorded information, the form of the alternation pattern being dependent upon the generation number of the previously recorded information.

7. A method as claimed in Claim 6, characterized in that the detected pattern is a periodic pattern, the ratio between the number of "copy" bits of a first logic value in a period the and total number of "copy" bits in said period being selected depending upon the generation number.

8. A method as claimed in Claim 5, 6 or 7, characterized in that the information being recorded is a standard CD signal.

9. An information recording device for obtaining a record carrier as claimed in Claim 1, 2, 3 or 4, which device is constructed to record on the record carrier main information together with a series of subcode frames which each comprise a "copy" bit, characterized in that the device comprises assignment means for assigning the logic values in accordance with an alternation pattern to the "copy" bits of consecutive subcode frames of information to be recorded.

10. An information recording device as claimed in Claim 9, characterized in that the assignment means comprise selection means for selecting an alternation pattern of a specific form from a plurality of patterns of predetermined forms depending upon a control signal.

11. An information recording device as claimed in Claim 10, characterized in that the selection means are adapted to select a periodic pattern whose ratio between the number of "copy" bits of a first logic

value in a period and the total number of "copy" bits in said period depends upon the control signal.

12. An information recording device as claimed in Claim 9, 10 or 11, characterized in that the device is adapted to record standard CD signals.

13. An information recording device for recording main information, which is received together with a series of subcode frames which each comprise a "copy" bit, which device comprises anti-copy means for inhibiting unauthorized copying of received information, which anti-copy means comprise decision means for deciding whether recording of received information is allowed depending upon the logic and means responsive to a decision that recording is not allowed to inhibit recording, characterized in that the device comprises detection means for detecting an alternation pattern in the logic values of the received "copy" bits, the decision means being adapted to decide whether recording is allowed depending upon the detection of the alternation pattern.

14. An information recording device as claimed in Claim 13, characterized in that the detection means are adapted to detect alternation patterns of different forms, the decision means being adapted to decide whether recording is allowed depending upon the form of the detected alternation pattern.

15. An information recording device as claimed in Claim 14, characterized in that the detection means are adapted to detect in a period of a periodically alternating pattern the ratio between the number of "copy" bits of a first logic value and the total number of "copy" bits in said period, the decision means being adapted to decide whether recording is permitted depending upon the detected ratio.

16. An information recording device as claimed in Claim 13, 14 or 15, for recording main information together with a series of second subcode frames, which each comprise a second copy bit, characterized in that the device comprises assignment means for assigning the logic values to the second "copy" bits of consecutive second subcode frames in accordance with an alternation pattern.

17. An information recording device as claimed in Claims 14 and 16, characterized in that the assignment means are adapted to assign the logic value to the second copy bit in accordance with a pattern whose form depends on the form of the detected alternation pattern in the logic values of the "copy" bits in the subcode frames of the received information.

18. An information recording device as claimed in Claims 15 and 17, characterized in that the assignment means are adapted to assign the logic values to the second copy bits in accordance with a periodic pattern, the ratio between second "copy" bits of a first logic value in a period and the total number of second copy bits in said period being dependent upon the detected ratio.

19. A recording device as claimed in any one of the Claims 13 to 19, characterized in that the device is adapted to receive information formatted in accordance with a standard audio interface format.

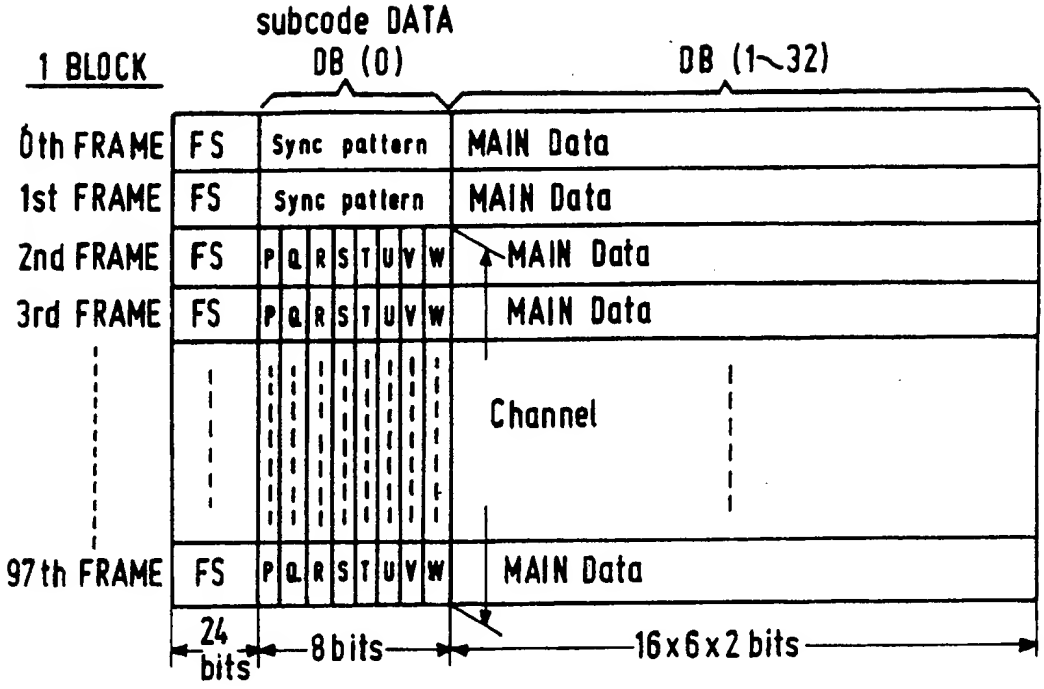
subcode DATA
1 BLOCK
DB (0)
DB (1~32)
0th FRAME
1st FRAME
2nd FRAME
3rd FRAME
97th FRAME
FS
Sync pattern
P Q R S T U V W
MAIN Data
Channel
24 bits
8 bits
16x6x2 bits

FIG.1

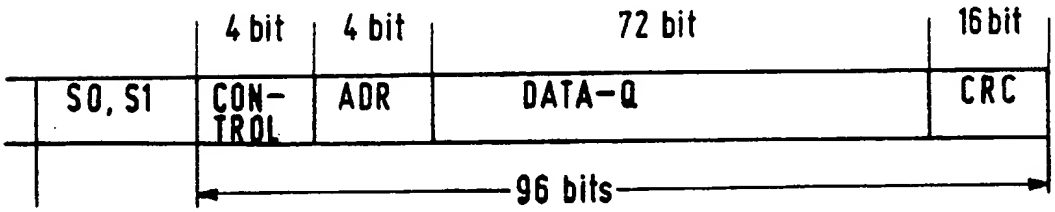
4 bit
4 bit
72 bit
16 bit
S0, S1
CON-TROL
ADR
DATA-Q
CRC
96 bits

FIG.2

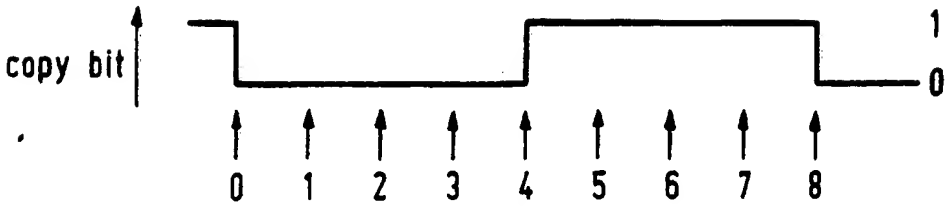

FIG.3

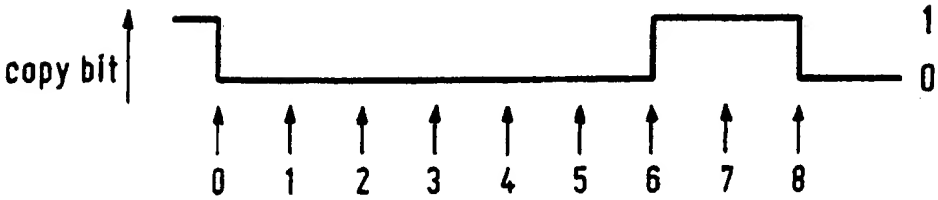

FIG.4

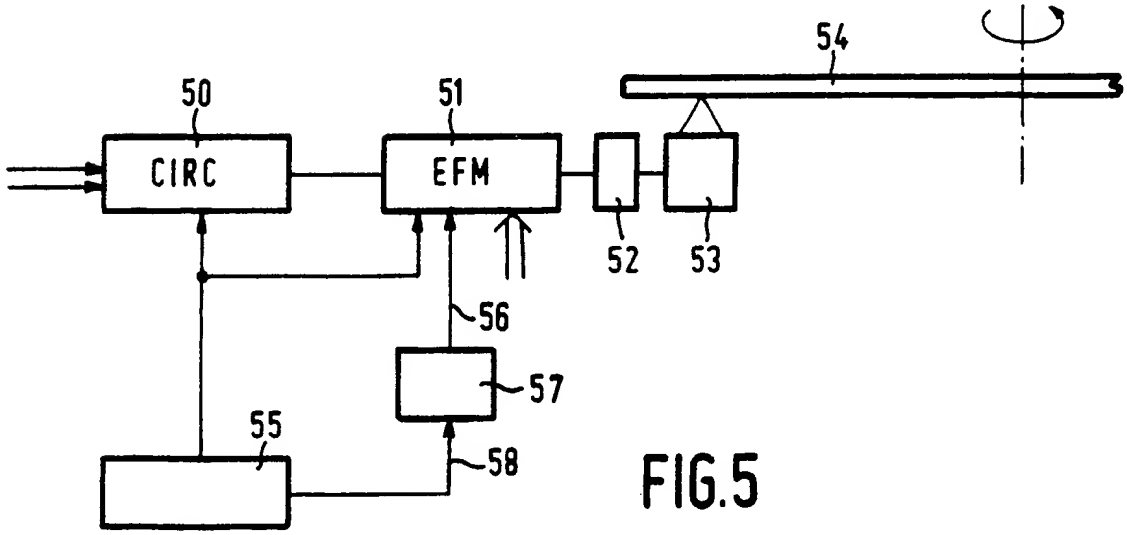

FIG.5

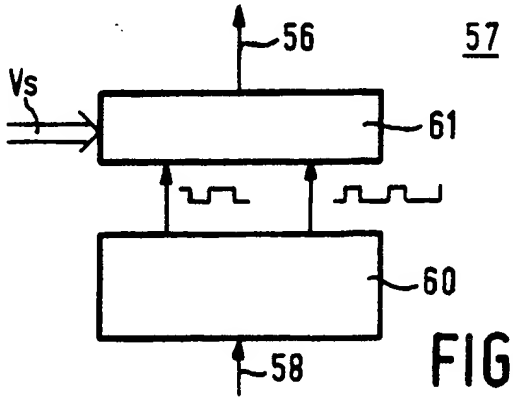

FIG.6

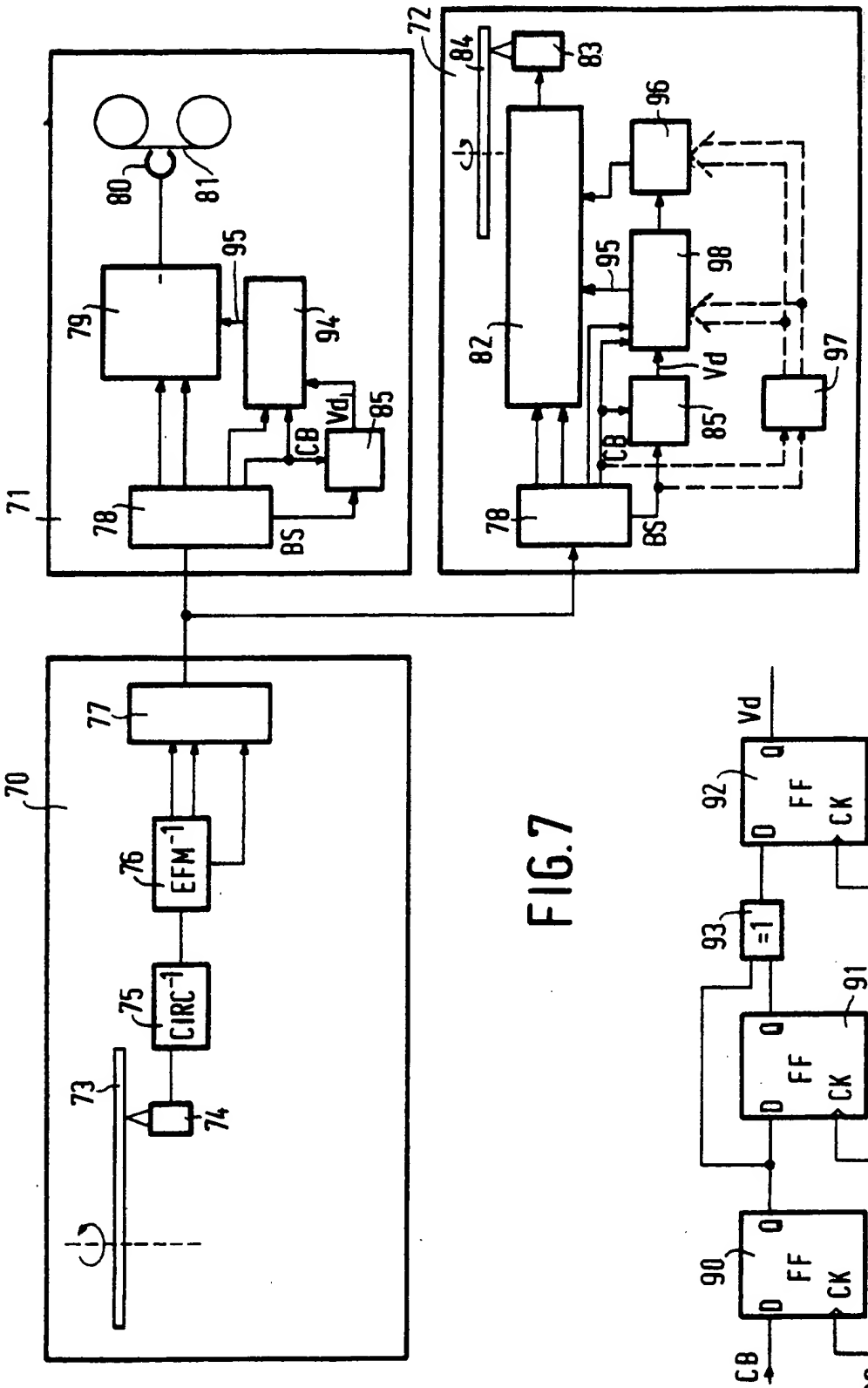
70
71
72
73
74
75
CIRC⁻¹
76
EFM⁻¹
77
78
79
80
81
82
83
84
85
Vd
CB
BS
94
95
96
97
98

FIG.7

Vd
92
FF
D
CK
Q
93
=1
91
90
CB
BC

FIG.8

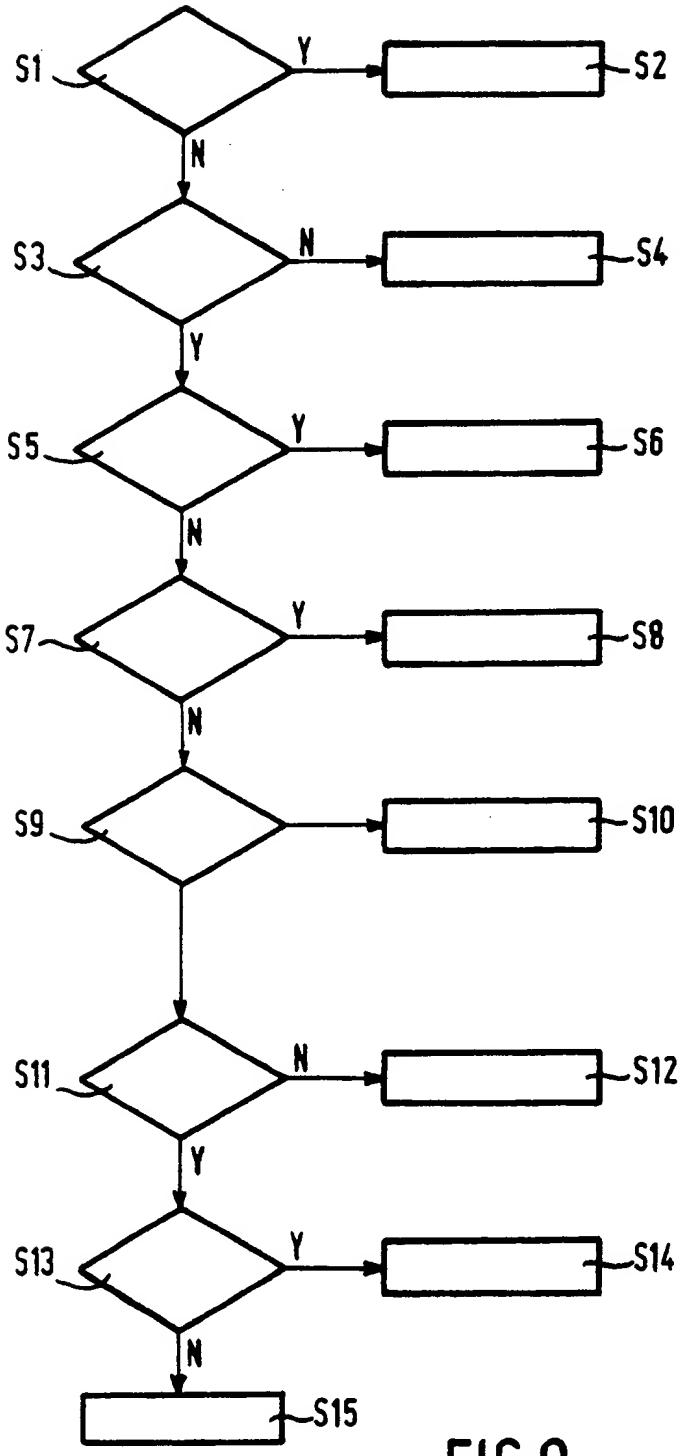

FIG.9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 20 2448

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 224 929 (SONY CORPORATION) * column 4, line 27 - column 5, line 15; figures 1-3 *	1	G 11 B 20/00
A	AUDIO. vol. 71, no. 3, March 1987, NEW YORK US pages 26 - 30; KEN POHLMANN: "MINDING YOUR P's AND Q's"		
A	EP-A-0 328 141 (MATSUSHITA ELECTRIC INDUSTRIAL CO.)		
A	EP-A-0 297 539 (KABUSHIKI KAISHA TOSHIBA)		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G 11 B

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	10 December 90	CARTRYSSE A.A.H.

CATEGORY OF CITED DOCUMENTS

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